

Review

The Nature and Articulation of Ethical Codes on Tailings Management in South Africa

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Abstract: It is well recognized that the mining industry in South Africa is highly rated for its substantial contribution to the country's economic growth, including employment and infrastructural development. It is also known that mining and ore processing activities potentially pose a severe threat to public health and environmental well-being, in the way operations are carried out, mine wastes are disposed of (in dumps), local communities are relocated, mine management and the mining community, in general, perceive established environmental standards and etiquette. This paper examines ethical practices and norms in the South African mining industry, with particular reference to the management of tailings dams. We analyse the modes of articulation of the country's regulatory instruments for tailings management, and review the corporate social responsibility (CSR) approach of leading mining companies. Despite decades of research and resulting recommendations on tailings management, it is concluded that the current legislations are largely ineffective, that the level of adherence by mine management and the mining community is low, and that the mechanisms for compliance monitoring is weak. New perspectives on legislative issues for unsolved problems in tailings handling are put forward, and directions for future research, indicated.

Keywords: mine tailings; ethics; legislations; corporate social responsibility; policy research; South Africa

1. Introduction

1.1. Background and Problem Statement

The Republic of South Africa remains one of the top 5 mining countries of the world [1,2]. From when gold mining started more than a century ago, until 2006, South Africa has been the largest producer of gold in the world [3,4].

Cronje et al. (2013) [5] acknowledge mining companies' contribution towards improved social development, in providing jobs, paying taxes, building an industrial base, enhancing efficiency, earning foreign exchange and transferring technology. On the other hand, some of these companies have been linked to a number of blatant public maleficent practices, including interference in sovereign affairs, deepening disparities in wealth, poor labour conditions, corruption, transfer pricing, and disrespect of human rights [5–7].

Some authors (e.g., [8–11]) however, consider the most worrying aspect of present day mining in South Africa to be the ethics of tailings handling and other mine waste disposal practices; and the impact these have on the health of surrounding communities and the environment as a whole, by way of pollution incidents, safety failings and reduction in the amount of space available for low-cost housing projects.

In this paper, the term “tailings” is used interchangeably with the broader term “mine residue deposits” (MRDs), which is used in South Africa to denote dumps, heaps, piles, fillings or tailings dams consisting of mine residue, which usually project above the natural ground surface, but may occupy the space of a pre-existing excavation [12].

Metalliferous mines in the country produce a substantial volume of mine waste. In the case of gold mining, for instance, in 1996 alone, a total volume of 377 million tons of mine waste were produced, accounting for 81% of the total waste stream in South Africa [13]. In 2007, Rademeyer [14] estimated that approximately 12,000 ha of land were sterilized by 150 MRDs in the Gauteng Province alone.

Only a small percentage of the total waste generated can potentially be backfilled into worked-out areas underground, and the bulk of it is deposited in large surface impoundments or tailings dams. According to RSA DEA (2012) [15], many of these dams are unlined and unvegetated (Figure 1). They constitute the largest single source of pollution of the soil, water and air environments in South Africa, including breakdowns in nutrient cycling (See Section 2, this article). Improper handling of tailings can cause the emission of extensive dust, as well as acidification and salinization of soils. The quantitative prediction and integration of these impacts is difficult to address, and the impacts are costly to manage and remedy.



Figure 1. Johannesburg’s Soweto Riverlea neighborhood in the shadow of a gold mine slag heap. Photograph: Alamy, 2015. Source: <http://www.theguardian.com/cities/2015/jul/06/radioactive-city-how-johannesburgs-townships-are-paying-for-its-mining-past> (accessed on 26 March 2016).

Since the dawn of the anti-apartheid era, a plethora of codes and statements of corporate social responsibility (CSR) have come into being. New constitutional reforms have been introduced, and a review of environmental and mining laws has been undertaken. In spite of these efforts, vestiges of exploitative colonial mining laws appear to be still firmly entrenched in the new legislation, and a number of other deficiencies remain. There are too many loop-holes. Strategies for effectively administering, monitoring and enforcing the new laws and policies are still in need of review.

As the mining and environmental legislation developed it became more and more difficult for the mining industry in South Africa to obtain a permit for closure. This has often been the result of unavailability of sufficient information for confidently predicting the long-term impact that the mine may have on nearby residents and on ecosystems around the mines. Another complicating factor is

that the information available is not always presented to authorities in a form that is understandable, practicable and reflective of pro-active management.

Legislative frameworks should be designed to help companies manage their tailings responsibly and safely and to be able to demonstrate this practice to regulators and the public, as well as to help companies implement due diligence. These frameworks should also provide a basis for developing customized management systems, exposing gaps within existing procedures, communicating with “communities of interest”, obtaining permits, conducting internal audits, and aiding compliance and due diligence, at all stages of the life cycle.

Sutton and Weiersbye (2007) [16] observe the non-provision of specific guidelines for the assessment of the sustainability and/or rehabilitation success. In the realm of tailings management proper disposal practices are still not strictly regulated, and current applicable guidelines for the planning and environmental management of disposal facilities are lax, are not strictly enforced, or are overruled. An overview of their contents and soundness (of guidelines documents), let alone their impact, is missing.

In this paper, therefore, we closely examine the nature of existing legislation and provide a critical review of the codes of corporate practice in tailings management in South Africa, as well as their mode of articulation. Areas of cumulative tailings management legislation that need clarification or further development are identified, and credible strategies proffered for re-visitation and revision of the new complementary regulations, so that they meet constitutional requirements, and better align with sound environmental principles. Tangible measures for compliance monitoring are recommended that would greatly help in enhancing the sustainable livelihoods of mining communities and the public.

Examples are provided that show concurrence with the observation of Fooks et al. (2013) [17], namely that the mining company’s interest in the practice of CSR resides largely in its potential to promote policy outcomes that work against the public welfare. Possible impediments to mar the translation of new research findings and policy initiatives into effective interventions are identified, and ways of obviating them are recommended.

1.2. Methodology

An exploratory approach was adopted in a comprehensive literature search and focus group discussions with relevant professionals and stakeholders, to assess the ethics of effective tailings management in South Africa. The documents retrieved from the literature search included peer reviewed journal articles and conference proceedings, authentic book chapters, published and unpublished theses and reports, and selected web references.

Firstly, an overview of the present state of tailings management in South Africa is presented, followed by the identification, analyses and syntheses of the characteristics, contents and significance of existing relevant national codes of conduct to bring out the strengths and weaknesses of current legislations, and to identify lessons learned and best practices. Findings on the current state of tailings management in the country are then corroborated with the provision of brief overviews of critical challenges and an analysis of issues relating to CSR, sustainable development, health and safety, and engagement between communities and mine operators. These findings were then used to develop specific policy recommendations to improve environmental and social standards in tailings handling.

Three particularly relevant and representative case studies are appended to cover a spectrum of potential negative environmental and social impacts of tailings management as well as illustrate some of the technical, socio-economic and governance challenges faced by industry and regulators in managing these impacts. Thorough examination of these case studies contributed towards the formulation of a basis for analyzing standards and approaches—either existing or under development—which aim to improve the environmental and social conditions in the tailings management sector.

There exists a large volume of documentation relating to all aspects of design, construction, operation and closure of tailings facilities in South Africa in the form of manuals, technical papers,

conference proceedings and textbooks (e.g., See [18]); and only a cursory reference is made in this review to the quality of tailings dam design and construction, and the engineering properties and composition of tailings.

We conclude by assessing future trends and charting policy options through the submission of five pertinent imperatives for effective tailings management.

2. Current Status of Tailings Management in South Africa

2.1. Stakeholders and Expectations

Key stakeholders in tailings management in South Africa include:

- Government;
- Mine management;
- Holders of prospecting or mining rights;
- Mine employees;
- Shareholders;
- Regulators;
- The affected community, which include the landowners, local authorities, business and service providers, community groups and non-governmental organizations (NGOs) [19,20].

There are some minimum expectations from each one of these stakeholder groups in achieving objectives in the drive towards attaining good management practices. A comprehensive tailings stewardship regime should include the protection of human health and a demonstration of a corporate commitment to social responsibility. Codes of practice should be crafted to engender the need for disposal practices to fall within the constraints of the law.

To avoid the manifestation of undue risks and ensure the optimization of resource exploitation, Snyman and Brent (2006) [21] propose that owners of mines and practitioners of mine residue disposal must conduct disposal practices in accordance with fundamental safety and environmental objectives, and principles as given in a set of performance criteria.

2.2. Handling Methods and Policies

Reichardt (2012) [22] has looked at the scientific factors that drove the evolution of mine waste management and rehabilitation techniques in South Africa, and sets out political, social and financial factors that influenced how this was turned into practice in the field. He also considers the role of personalities and the organizational constraints in which they operated in order to implement these techniques.

Present methods for the transport, deposition and storage of tailings in South Africa still use conventional techniques which are based on moving large volumes of very wet, low-density slurries (Figure 2). This approach involves the use of large volumes of water and can have negative consequences, in that much of the water is often lost during the operation [21,23] (Vermeulen, 2001; Snyman and Brent, 2006). Another important issue associated with the storage of fluid residue, concerns the environmental impacts associated with acid mine drainage (AMD) and land sterilization.

Although significant progress has been made in shifting policy frameworks to ensure responsible and effective stewardship of tailings facilities, loopholes in the current management systems still remain; for example, in policies relating to engineering design and construction of dams, and installation of water storage facilities. Existing standards and guidelines documents do not contain articles that specifically prescribe how these constructions should be done in order to obviate negative environmental impacts including health and safety concerns; but place more focus on the need for management throughout the life cycle of the facilities. The guidelines only require that the facilities be managed by appropriately qualified persons, often professional engineers, over their entire life cycle [18,24] (Anglo American, 2005; Robertson and Caldwell, 2015).



Figure 2. Gold tailings dam, Johannesburg, South Africa. Credit: EXTRACTEX, 2016. Source: http://www.extrac-tec.com/wp-content/gallery/mining-application/4gold-tailings_sa02.jpg (accessed on 26 March 2016).

In the prescription of project management models for the development of new tailings facilities, the guidelines do not even provide a holistic approach for integrating the requirements of the environmental impact assessment (EIA) legislation and the requirements of the South African Bureau of Standards (SABS) Code of Practice [25] (SABS, 1998) during the various project life cycle phases in order to optimize the overall implementation process [21] (Snyman and Brent, 2006).

2.3. Environmental Health Issues and the Plight of Womenfolk

Cronje et al. (2013) [5] have listed the social factors that precipitate health disasters in communities associated with management of South Africa's tailings dams. These include poverty, unemployment, poor housing and infrastructure, prostitution and a high influx of unaccompanied migrant labour. In many instances, women bear the brunt of these maladies. Available jobs are given without cognizance of any gender balance.

It is a misconception that local communities are against mining. A direct quote from Mannak (2012) [26] summarizes the existing situation quite well: "People in South Africa are desperate for jobs and appreciate what mining can do for them financially. They are however worried about a lack of information, not knowing what their rights are, loss of land, safety of their children, water pollution and their health—among other things."

Major health-related issues among workers and residents brought directly or indirectly by poor tailings handling include exposure to a toxic mix of radioactive elements (Figure 3), arsenic and heavy metals, loss of biodiversity, impairment of ecosystem services, contributions to ozone depletion and global warming. Harmful particulate matter in the air may result in respiratory illnesses.

Tailings facilities at abandoned and old mine sites cause water pollution and AMD. Contamination of both groundwater and surface water deprives subsistence farmers and large agricultural businesses of water. Cattle and grazing land is affected, depriving communities of an income. A review of these factors by Cronje et al. (2013) [5] led to the conclusion that "... communities need to be 'fenced in' in terms of health disaster management instead of being excluded."

Women often make up more than 50 percent of a community and form an integral part of the country's land owners [27]. They are thus more susceptible to the social and environmental health impacts of improper tailings management. The majority of geophagists (people who deliberately, or sometimes inadvertently, consume soil) are women. As is now well established, soil around tailings

dams often carry a large burden of toxic metals and other contaminants (Figure 3; [28]). These are exactly why the question of inclusivity (See Section 5.1, this article) is so important for women. Indeed, as McGuire (2003) [27] points out, consultation on the environmental impacts of mining needs to be gender specific to encourage women to discuss issues which pertain to their roles in the provision of health care, education, food security and cultural activities (ceremony) (See Section 5.2, this article).



Figure 3. Mining communities in the Witwatersrand goldfields are often built near, or on top of, tailings piles that contain uranium dust. Credit: Stephan du Toit, 2011. Source: <http://www.earthmagazine.org/article/all-glitters-acid-mine-drainage-toxic-legacy-gold-mining-south-africa> (accessed on 26 March 2016).

3. Relevant Legislation and Modes of Articulation

Mining activities constitute one of the listed activities that should be regulated to give effect to the environmental rights provided in the South African Constitution. As a result of the new legislations and older, but still applicable, regulations, a range of applications had to be prepared and submitted to different governmental organisations prior to implementing a new tailings disposal plan.

The principal South African legislation that is currently applicable to tailings dam management include:

- I. The Constitution of the Republic of South Africa Act No. 108 of 1996 (CRSA);
- II. The Mineral and Petroleum Resources Development Act No. 28 of 2002 (MPRDA);
- III. The Code of Practice for Mine Residue Deposits (CPMRD);
- IV. The National Environmental Management Act No. 107 of 1998 (NEMA);
- V. The National Water Act No. 36 of 1998 (NWA);
- VI. The Minerals Act No. 50 of 1991;
- VII. The National Environmental Management: Waste Act No. 59 of 2008 (NEMWA);
- VIII. The National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA);
- IX. The Mine Health and Safety Act 29 of 1996 (MHSA);
- X. The Radioactive Waste Management Policy and Strategy for the Republic of South Africa (RWMPS).

A cursory look at this legislation reveals loop-holes, as the ensuing discussion will show. The circumstances where a specific piece of legislation should be applied (e.g., in tailings management)

and the mode of its articulation, remain unclear. Although the legislation is imbued with human values and judgments, ethics seldom forms a part of the entire implementation and monitoring chain. Mine management principles are often below policy and political implications, and there is often a lack of understanding of the interrelationships between the different regulations, and the involvement of the different government departments.

3.1. The Constitution of the Republic of South Africa Act No. 108 of 1996

The Constitution of the Republic of South Africa Act No. 108 (of 1996a) (several amendments thereafter), Section 24, provides *inter alia*, “... that everyone has the right to an environment that is not harmful to health and well-being ... ” [29]. The promulgation of new environmental legislations in mining- and other sectors, following the advent of democracy in the country, became necessary to give legal effect to the principles of sustainability, as spelled out in the CRSA. As a result, the NEMA and the NWA were promulgated in 1998; and the MPRDA, dealing specifically with mining activities, in 2002 (See later Sections 3.2, 3.4 and 3.5, this article).

Section 195 (1) of the CRSA, sets out ethical values and principles, which must be held by all public servants and organs of state in carrying out their duties. Mining activities are one of the main listed activities that should be regulated to give effect to the environmental rights provided in the CRSA [21]. Furthermore, Section 24 (b) of the CRSA provides measures for ensuring a safe environment in mining and the disposal of resulting waste; it also reiterates the moral obligation of mine management to prioritize the health of communities and environmental integrity during all phases of mine development, including closure, as is further imbued in NEMA (See Section 3.4, this article).

However, in spite of the proclamation in Section 195 (1) of the CRSA, when considering the effect of (improper) tailings handling, experience and conditions on the ground support the view that, in many instances, the constitutional rights of communities affected by mine pollution are often infringed (See e.g., Appendix A–C, this article).

3.2. The Mineral and Petroleum Resources Development Act No. 28 of 2002

The MRPDA (of 2002) (date of commencement, 1 May 2004) states: “To make provision for equitable access to and sustainable development of the nation’s mineral and petroleum resources; and to provide for matters connected therewith”, requires a mine to have an environmental management program report, which becomes legally binding [30]. The report should contain the results of studies undertaken by the mining company to determine the quantum required for the rehabilitation or management of impacts, and to make sufficient financial provision for these. But it is argued that this is only applicable to the mine site.

The majority of the mine dumps which still dominate the South African mining landscape today are dumps created prior to the promulgation of the MRPDA. Although the old MRPDA does aim to provide for the protection of the environment at mine closure, Sutton and Weiersbye (2007) [16] noted that it contains some flaws and gaps which needed to be addressed.

For example, from a mining regulatory point of view, the government agencies did not appear to have any control over those mine dumps [16,31]. What that also meant was that the common law position relating to the ownership of mine dumps, despite the other fundamental changes to the mining legislation, still prevailed.

The Department of Mineral Resources (DMR) has attempted to correct this situation, and to ensure that Government, from a regulatory perspective, secures control over the historic mine dumps. This was done, firstly, by promulgation of the Mineral and Petroleum Resources Amendment Act 49 of 2008 (amendment to the earlier MRPDA), of which certain sections came into effect on 7 June 2013; and now, by means of the Mineral and Petroleum Resources Development Amendment Bill of 2013 [31,32]. Articles in the Amendment Act are now signed into law, but unfortunately, these are still unclear and certain clauses seem unworkable.

3.3. The Code of Practice for Mine Residue Deposits

Published back in 1998 by the South African Bureau of Standards (SABS, 1998), the principal management “Guidance Document” for management of tailings facilities in South Africa is the CPMRD [33]. This standard is referred to as SABS 0286:1998 [later re-named SANS (South African National Standards) 10286]. Articles in this Document engender the implementation of a code of practice that is mandatory for each tailings facility [18]. It contains the fundamental objectives, principles and minimum requirements for best practice, all aimed at ensuring that no unavoidable risks, problems and/or legacies are left to future generations [34].

The standard was developed as a consequence of a major tailings impoundment failure in Virginia in the Free State in February 1994 (See Appendix A, this article), to address safety concerns relating to the structural failure, and how to prevent this from recurring. There are some inherent gaps in the Standards, such as provision of sufficient latitude for integrating the requirements of the EIA legislation, although these are potentially addressed by the provisions of other legislations such as the NEMA and NWA. The regulatory framework for mining residue stockpiles and deposits which has been under review [35], has been replaced (in 2015) by a new set of requirements for mine dumps and stockpiles.

Proclamation of new “Mining Residue Regulations” (MRR) was made by the Department of Environmental Affairs (DEA) on 24 July 2015 in order to control the establishment and reclamation of mine dumps and stockpiles of similar waste from, or incidental to, mining operations [36]. These activities must now comply with the new regulations.

The MRR supersede regulation 73 of the MPRDA, which previously regulated mining waste. Most of the provisions in the new MRR, however, echo those in regulation 73 of the MPRDA, albeit with some significant changes [37]. For example, a waste management licence under NEMWA is now required for the creation of a residue stockpile, and an EIA process must be undertaken in accordance with NEMWA. Whereas under the old MPRDA regulations, any registered engineer could design stockpiles where stockpiles had to be designed by a “competent person”, the MRR now require that this be done by a civil or mining engineer, registered under the Engineering Profession of South Africa Act 114 of 1990. Stockpiles must also now comply with landfill requirements, the “National Norms and Standards for the Assessment of Waste for Landfill Disposal, 2013”, and the “National Norms and Standards for Disposal of Waste to Landfill, 2013”.

Cullinan (2015) [37] considers that the new MRR make the requirements for establishing and managing stockpiles and residue deposits more stringent and more expensive, but acknowledges that they would lead to an enhancement in preventive measures.

Later reviews of regulations regarding the planning and management of residue stockpiles and residue deposits (e.g., [38]) have advocated amendment legislations that would, *inter alia*, “allow for the pollution control barrier system required for residue stockpiles and residue deposits to be determined on a case by case basis, based on a risk analysis conducted by a competent person”; and the use of a “pollution control barrier system compliant with the commensurate norms and standards for disposal of waste to landfill determined as a result of the risk analysis.”

3.4. National Environmental Management Act No. 107 of 1998

The NEMA reads: “To provide for co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote cooperative governance and procedures for co-ordinating environmental functions exercised by organs of state; to provide for certain aspects of the administration and enforcement of other environmental management laws; and to provide for matters connected therewith”. Long title amended by Section 3 of Act No. 56/2002, and substituted by Section 13 of Act No. 46/2003) [39].

The NEMA as amended, provides a broad, flexible legislative framework for environmental management in South Africa. It provides for cooperative environmental governance, and defines principles for decision-making on matters affecting the environment. Feris and Kotzé (2014) [40]

also noted that it provided a medium for responding to changes in socio-economic and ecological parameters. The application of this legislation, it was hoped, would help in protecting environmental resources and regulate harmful impacts on the environment. Also embedded in the amended Act, are articles pointing to the need for caution to be taken to ensure that the application of policies or related regulatory measures intended at protecting the environment should uphold the human rights values such as equality and dignity [31]. The upholding of equality and dignity values helps in ensuring the consistent application of policies and avoiding creating false perception of the marginalized communities, which could result in sustaining the structural disadvantage in unequal societies.

3.5. The National Water Act No. 36 of 1998

The International Commission on Large Dams (ICOLD) is a non-governmental international organization which provides a forum for the exchange of knowledge and experience in dam engineering. Based on the principles enshrined in ICOLD's flagship document on dam safety, the first dam safety legislation in South Africa was promulgated by the then Ministry of Water Affairs way back in 1986 [41,42].

By the start of the post-apartheid environmental campaign in the mid 1990s, water was already deemed a common property resource owned by the people of South Africa and managed by the Government [43]. The National Water Policy White Paper and the NWA are based on the principles of equity, sustainability and efficiency [44]. The NWA was amended in 1999 by the National Water Amendment Act No. 45 of 1999 (See Government Gazette No. 20706 of 6 December 1999).

The implementation of the amended NWA in 1999, as well as floods in 2000, and droughts at that same time, forced the introduction of water tariffs, and brought attention to mine water issues [45]. Questions then arose on how the additional legislation in the form of the MPRDA will affect already existing uncertainties arising from the implementation of the NWA [45].

In 2007, the Department of Water Resources and Forestry (DWAF) published the "Best Practice Guidelines for Water Resource Protection in the South African Mining Industry", Document BPG A4: Pollution Control Dams (PCDs) [46]. The BPG A4 Document gives the purpose and general principles of PCDs. In order to classify the geochemistry of the tailings a subsidiary to this Act came into consideration, *viz.*, the Minimum Requirements Guidelines of the Department of Water Affairs, which is referenced in the MPRDA [47], including environmental legislations that cover other waste products.

According to Mukheibir and Sparks (2003) [48], the country's new water laws have instituted a macroeconomic and environmental reform process in the sector, in which water rights have been separated from land rights and a "water right", limited to a "use-right".

From the perspective of tailings handling, the water laws appear to lack proactivity with respect to developing the relevant protocols, monitoring programs and operating procedures [45]. Even if there are no formal DWAF guidelines, advice on how this process can be set in motion should be provided directly by DWAF or by private consultants. This proactive approach, Cessford (2004) [45] went on to note, would ensure that formalizing existing water uses and applying for new licences would be a relatively painless exercise. It would also provide consolidation with commitment to DWAF (and other stakeholders) that water be used optimally.

3.6. The Minerals Act No. 50 of 1991

The Minerals Act No. 50 of 1991 was put in place: "To regulate the prospecting for, and the optimal exploitation, processing and utilisation of, minerals; to regulate the orderly utilisation and the rehabilitation of the surface of land during and after prospecting and mining operations; and to provide for matters connected therewith" [49]. The Act provides statutory requirements enforcing environmental protection, the management of the environmental impacts and the rehabilitation of the affected environment of prospecting and mining in South Africa.

According to Swart (2003) [20], the most important requirement concerning the environment and the rehabilitation thereof, is that an environmental management plan (EMP) based on an EIA, must be submitted and officially approved. The Minerals Act (1991) requires in Section 38, that the

rehabilitation of the surface of land concerned in any prospecting or mining shall be carried out by the holder of the prospecting permit or mining authorization concerned, in accordance with the EMP approved in terms of Section 39 of the Act; and as an integral part of the prospecting or mining operations concerned throughout the life of the operation, until closure.

An amended version of the EMP was published by the Department of Minerals and Energy (DME) in February, 2001, under Section 15 (2) (b) of the NEMA (of 1998) [50]. The inclusion of monitoring and performance assessment into the mining environmental management process is meant to complete the last link of an integrated, cradle-to-grave environmental management process adopted by the DME [20]. The monitoring and EMP performance assessment process also assists Government as well as the mining industry in determining compliance with the requirements of the EMP, the appropriateness of the EMP, and to guide mines towards effective and acceptable closure.

3.7. National Environmental Management: Waste Act No. 59 of 2008

Waste management in South Africa is governed by the NEMWA (of 2008), which came into effect on 1 July 2009. It states: "To reform the law regulating waste management in order to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development; to provide for institutional arrangements and planning matters; to provide for national norms and standards for regulating the management of waste by all spheres of government; to provide for specific waste management measures; to provide for the licensing and control of waste management activities; to provide for the remediation of contaminated land; to provide for the national waste information system; to provide for compliance and enforcement; and to provide for matters connected therewith."

Following the enactment of the NEMWA (of 2008), the Ministry of Environmental Affairs (MEA) established the National Waste Management Strategy (NWMS) in terms of Section 6 (1) of the NEMWA for achieving the objects of the Act. The NWMS was approved for implementation by the Cabinet in November 2011. The NEMWA supports the waste management hierarchy in its approach to waste management, by promoting cleaner production, waste minimization, reuse, recycling and waste treatment, with disposal seen as a last resort in the management of waste.

General, hazardous and industrial wastes from the mining industry also fall within the scope of the NEMWA, and therefore are addressed by the NWMS. However, Section 4 (1) (b) of the NEMWA specifically excludes residue deposits and stockpiles from its ambit, as much as these are regulated in terms of the MPRDA. In terms of the amendment to the MPRDA, responsibility for the performance of environmental authorizations was reverted to the DEA. The promulgation of the National Environmental Management Laws Amendment Act No. 25 of 2014 (NEMLAA), amended the Waste Act to include residue stockpiles and deposits [51]. The reasoning for setting aside NEMLAA was that it required residue stockpiles and deposits to be managed in the "prescribed manner".

3.8. The National Environmental Management: Air Quality Act 39 of 2004

The original Act regulating air quality, the Atmospheric Pollution Prevention Act No. 45 (APPA), was promulgated way back in 1965. It provided for the prevention of pollution of the atmosphere, for the establishment of a National Air Pollution Advisory Committee, and for matters incidental thereto [52]. The obligations contained in terms of the APPA with respect to the prevention and control of dust pollution are in addition to- and complimentary with, the obligations imposed by the Minerals Act No. 50 of 1991 (see Section 3.6, this article). The APPA is now superseded by the NEMAQA.

The NEMAQA was promulgated in 2004, "... for reforming the law regulating air quality, in order to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation, and for securing ecologically sustainable development, while promoting justifiable economic and social development" [53]. Further, the Act provides for national norms and standards regulating air quality monitoring, management and control by all spheres of government for specific air quality measures; and for matters incidental thereto [53].

Principles from Chapter 1 of the NEMA (See Section 3.4, this article) that are relevant to air pollution are:

- pollution avoidance or minimization—that pollution and degradation of the environment must be avoided, or, where they cannot be altogether avoided, are minimized and remedied;
- waste avoidance and consideration of life cycle assessment—that waste is avoided, or where it cannot be altogether avoided, it must be minimized and re-used or recycled where possible, or disposed of in a responsible manner [39].

3.9. The Mine Health and Safety Act 29 of 1996

The Republic of South Africa MHSA (of 1996) “... provides for protection of the health and safety of employees and other persons at mines” [29].

The Act is administered by the Mine Health and Safety Inspectorate of the DME. The following sections apply to tailings handling and mine closure employees:

- Sections 2 and 5, where the employer must ensure and maintain a safe and healthy environment at the mine, during commissioning, operation, decommissioning and closure;
- Sections 6, 10 and 11 make provision for the employer to provide and supply adequate health and safety equipment and training, and to assess and respond to any risk or hazard to which employees may be exposed;
- Sections 12 and 13 pertain to the medical surveillance system;
- Sections 19, 22 and 23 pertain to employees’ rights with regard to access to information, duties for health and safety and permission to leave a dangerous working place if circumstances arise [54].

3.10. The Radioactive Waste Management Policy and Strategy for the Republic of South Africa

The vision of the South African Government regarding radioactive waste is that: “The management of radioactive waste shall be in accordance with national objectives and recognized international principles as set out in Government Policy” [55]. The aspect of internationalization imbued in this vision, adjures elements in the review of ethical and environmental considerations that must be taken into account in the long term management of radioactive wastes by the World Nuclear Association [56]. Thankfully, the Association noted in its 2006 Document, that there has been a steady growth in public appreciation (globally) that nuclear sites now operate safely with due care for the protection of people and the environment. This (positive) appraisal is a natural consequence of comprehensive health, safety and environmental programs that conform with general regulatory frameworks worldwide, and not specifically to any country or region.

As recently as the mid-2000s, radioactive waste in South Africa was managed without a common framework [55]. “The Radioactive Waste Management Policy and Strategy for the Republic of South Africa” was put in place in 2005 to correct this. The purpose of the Document was: “To ensure the establishment of a comprehensive radioactive waste governance framework by formulating, additional to nuclear and other applicable legislations, a policy and implementation strategy in consultation with all stakeholders” [55].

There exist a number of earlier legislations regulating radioactive waste disposal in South Africa, which together with the later Acts, make identification of the Act that is applicable in a particular situation, and its mode of articulation, confusing. A few of the earlier (waste) Acts that have sections relevant to tailings disposal are now briefly reviewed.

The NEMWA excludes radioactive waste and mining “residue deposits and residue stockpiles” from its ambit. It states that these are regulated in terms of the National Nuclear Regulator Act No. 47 of 1999 (NNRA), the Minerals Act and the MPRDA, among others. In reality, they are not, for as Lieferink (2011) [57] noted, the NNRA and MPRDA applied only to waste actually on a mine property, and not that outside it. Any spillage, or migration, of radioactive and toxic waste is therefore not

regulated under the MPRDA. Nor was it regulated in terms of the NNRA, which only regulated this waste when it was on mine property.

The more recently proclaimed National Radioactive Waste Disposal Institute Act No. 53 of 2008 (NRWDIA) states: “To provide for the establishment of a National Radioactive Waste Disposal Institute in order to manage radioactive waste disposal on a national basis; to provide for its functions and for the manner in which it is to be managed; to regulate its staff matters; and to provide for matters connected therewith”. Among the Institute’s specific functions are (i) the design and implementation of disposal solutions for all classes of radioactive waste; and (ii) the development of radioactive waste acceptance and disposal criteria in compliance with applicable regulatory health and safety environmental requirements, and any other technical and operational requirements.

4. Ethical Values and CSR

Before the beginning of the 2000s the absence of a widely agreed framework for defining CSR in mining circles was already apparent (e.g., [58]). The concept did not specify minimum outcome-based standards of health and social enabling milieu for companies whose activities are harmful to the health and social well-being of communities. Mining companies were able to externalize many of their costs to pass themselves off as socially responsible. What this did in practice, according to [17], was “... to involve mining companies in the use of CSR to broker access to public officials, influence the policy alternatives under consideration by elected representatives, break up opposing political constituencies, rebuild companies’ reputations as providers of reliable information and as a platform for strategic regulation.” Capel (2012) [59] cites reports of blackmail, lack of cooperation by mining houses, and involvement of current and former government officials as shareholders, board members or managers in mining companies, all of which actions present a whole set of complications and tensions. Before the new environmental dispensation, there was no general agreement on how to create indicators to assess the social responsibility of mining enterprises (cf. [60]). Moreover, studies that systematically compare codes of mining firms from different countries were generally lacking. In addition, examinations of contents of codes by different actors—governments, social interest groups and firms themselves—were rather inadequate [58]. Finally, the policy challenges created by the interaction of often rival codes were hardly addressed [58].

4.1. Present Status in Articulation of CSR in South African Mining

In South Africa today, all stakeholders in the mining industry recognize that in order to ensure that social environment needs are addressed during the life of the mines, and during post-closure, mines have to contribute towards social and economic development in areas where they operate, and in areas where they source their labour [7,17,61,62]. However, according to [63], the South African Companies (SAC) Act 61 of 1973 does not oblige companies to engage in CSR projects, although the country’s Policy Document and the King Reports (Section 4.1.1, this article) explicitly address the need and relevance for corporations to acknowledge all stakeholders and to adopt a “triple-bottom line” approach. It should be noted, however, that certain mining companies have long seen this need (even before the SAC Act 61 of 1973 and the more recent King Reports), and are willing to take responsibility for their company’s effects on environmental and social wellbeing. Some have even applied efforts that go beyond what may be required by regulators or environmental protection groups. Sadly though, there are still many mining companies that use CSR to produce policy outcomes that work against public welfare; and, according to [17], our understanding of the limitations of CSR as a means of aligning business activity with the broader public interest, remains relatively low.

Recently, Diale (2014) [7] provided an assessment of the progress made by South African mining companies in pursuit of responsible business practices. He refers to the notion of CSR as a discourse, and explains how it is conceived within the mining industry. Diale (2014) [7] further reflects on the Mining Charter as a framework for responsible business within the mining industry and analyses

the progress achieved so far. The Mining Charter is the broad-based socio-economic empowerment Charter for the South African Mining and Minerals industry [64].

Developments that have led to Diale's (2014) [7] observations are summarized in the earlier works of [65], who had compared corporate priorities of corporate governance, CSR and sustainability within the South African mining industry, and showed that social performance is the most highly reported sustainability dimension.

Finally, according to [17], "... the extent to which CSR practices can bring corporate activity more closely into line with the broader public interest is predicated on their capacity to make corporations more accountable to stakeholders whose interests are not purely confined to optimising returns on capital invested."

4.1.1. The King Reports—The "Codex" of South African CSR

South Africa's corporate governance guidelines and standards are contained and institutionalized in the well-known King reports [66], the first of which was issued in 1994 by the King Committee on Corporate Governance. Today, these reports are regarded as state-of-the-art guidelines regarding good corporate governance, and their adoption is highly popular, with many legislators recommending it as apposite for modulating the country's business sphere.

The first King Report or King I was published in 1994. It aimed at promoting corporate governance and adherence to adequate standards for board of directors of listed companies, financial institutions and some public enterprises [67].

Published in 2002, the King II Report clearly established and explained the seven good corporate governance elements that any corporation adopting the Report should pay attention to: discipline, transparency, fairness, social responsibility, independence, accountability and responsibility [66].

The revised code and report on "Governance Principles for South Africa" (King III) were released on 1 September 2009, and came into effect on 1 March 2010. The report focuses on sustainability and risk issues, while continuing to highlight the importance for companies to respond to all stakeholders [68]. The topics covered in the report are: ethical leadership and corporate citizenship, boards and directors, audit committees, the governance of risk, the governance of information technology, compliance with laws, rules, codes and standards, internal audit, governing stakeholder relationships and integrated reporting and disclosure. The latest King Report (King IV) was released in November 2016. It promulgates the integration of corporate governance into organizational practices with clear outcomes on addressing "ethical culture, good performance and effective control" [69]. Accordingly, the mining management ethical leadership role is to ensure conducting of business in ways that show respect of stakeholder interests, being responsible and accountable for own actions as well as ensuring fair play and transparency at all times. The ultimate aim being to prevent negative effects of an organization's activities on both the society and the environment in which they operate.

4.1.2. The Concept of Neutralization

Writing on different company approaches to CSR practices, Fooks et al. (2013) [17] used the tobacco industry as an example to show how the concept of "neutralization" can help us understand why companies only superficially address the important ethical issues.

Corporate decision-makers, when facing a combination of social censure and increased regulatory risk (manifestations of declining political authority), at first reject, and then contest the arguments of policy entrepreneurs and reform minded policymakers using techniques of neutralization. Fooks et al. (2013) [17] present a tripartite model of the neutralization process (Figure 4)—in the first of which, reliance by corporate decision-makers on techniques of neutralization provides the basis for declining political authority to be seen as a problem arising from poorly designed and coordinated political strategies (rather than a growing awareness of the company's conduct and its social impacts).

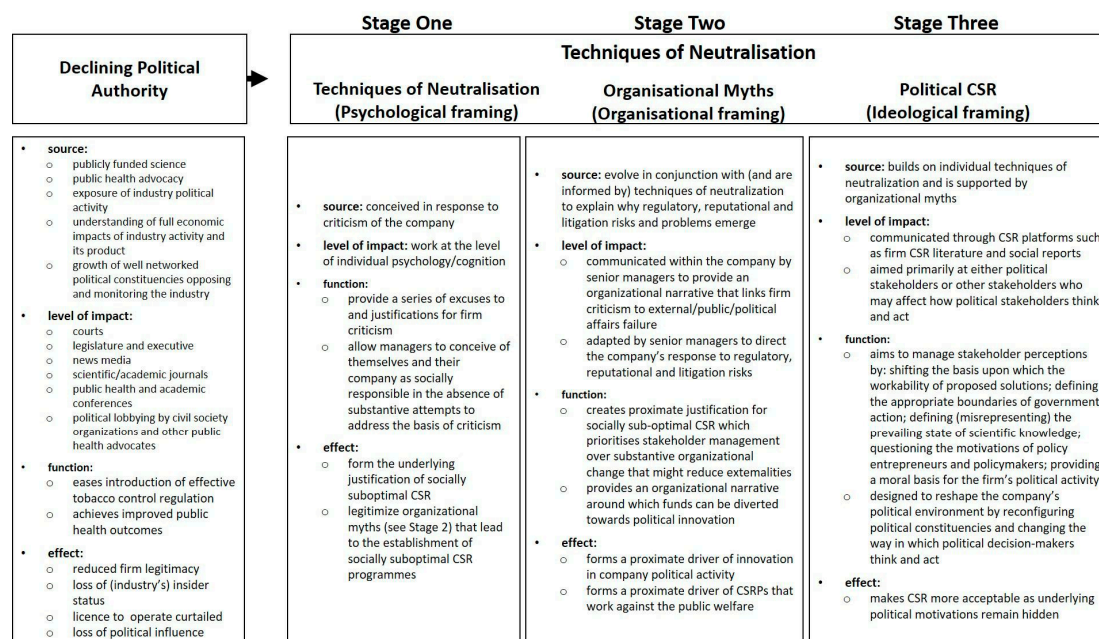


Figure 4. Techniques of neutralisation as they apply to corporate actors. Source: Adapted from [17].

During the second stage, according to the model of [17], corporate decision-makers start attributing the company's declining political authority to external social actors and proceed to design alternative—and potentially more effective—forms of political management (namely CSR) to annul their impact. In the third stage, corporate decision-makers embed techniques of neutralization within the firm's CSR to legitimize CSR practices that work against public welfare (by reducing political support for regulatory change).

This explanation by Fooks et al. (2013) [17] of the neutralization concept could, perhaps, with minor modification be applied in understanding the way tailings disposal operatives perceive ethical issues. They see their resistance to regulatory change as consistent with the broader public interest, and try to draw a distinction between sensible and unreasonable regulation, and building a constructive case for the company's existing commercial freedoms.

4.2. Compliance Monitoring

Kolk et al. (1999) [58] have observed that the likelihood of compliance depends on the contents of the code addressed, but is also heavily influenced by the interaction of various stakeholders in its formulation and implementation. According to [59], "... there is a role for independent monitoring and evaluation and a role for community monitoring to hold mining corporations accountable".

Nowhere is the problem of compliance, implementation and enforcement of laws more problematic than in the realm of EIAs [59]. In some cases, communities are not consulted as prescribed in legislation (See Section 5.1, this article), while in many other instances, only token public consultation processes are undertaken by mining companies to make it look as if they are complying with the law. Capel (2012) [59] asserts that these mining companies really have no intention of listening to local people or implementing concrete steps to curb environmental damage and protect communities. Furthermore, most EIAs appear to be based on the incorrect assumptions by mining companies and their consultants, who believe they have ready-made solutions to potential problems.

Another flaw of EIAs according to [59], is that they are produced by the mining company or developer of the project, and this means there is no independent assessment. Meanwhile, effective implementation and monitoring is often restricted by the relevant ministry's lack of financial and human resources. It is perhaps in the area of compliance monitoring where community participation, which also takes into account gender sensitivity, in policy formulation, is most strongly desired.

5. Mining Ethics and Sustainability in Tailings Management

By the advent of the new environmental dispensation in South Africa in the mid-1990s, the mining industry had taken note of the continued and growing momentum behind sustainable development [70]. Busacca (2013) [71] examines how concerns about the social responsibility and sustainability of South Africa's mining industries have become increasingly important and mainstream in recent years. A look at the historical evolution of the legislative processes regulating management of tailings dams in South Africa reveals that standards and guidelines are becoming increasingly prescriptive as regards procedural and technical requirements. There is some convergence around the norm for the design of a tailings disposal facility, and sustainability is now a closure requirement [72]. However, institutional factors as well as non-effectiveness and inefficiency of guideline dissemination and implementation strategies do not make for sustainability.

Corporate citizenship and sustainability require business decision makers to adopt a holistic approach to economic, social, and environmental issues in their core business strategy, and according to [73], only a holistic approach will allow for the effective management of business opportunities and risks. The implementation of sustainable development implies also a governance system that ensures the participation of all in the decision making process [74]; See Sections 5.1 and 5.2, this article). According to [75], there could be no single complete answer, but rather an elaboration of the complexity of the topic. On the issue of mine closure alone, for instance, sustainability has many profound ramifications, including environmental acceptability, safety, long-term stability, and hydrological considerations (See [76,77]). Above all, the future of the workers and the community is paramount, since they are threatened with no livelihood after cessation of the mining activity.

5.1. Inclusivity

Grunwald (2015) [78] has noted that all members of the society must have the opportunity to participate in societally relevant decision-making processes, especially regarding those decisions that are of key importance for the future development and shaping of the society.

In South Africa, the communication with communities affected by inappropriate tailings management is weak. They are merely informed of management decisions, but their consent is seldom sought. It is worth noting what the Alternative Mining Indaba in 2014 [79] had to say (direct quotation): "We continue to note with concern, that the African Mining Indaba (being held at the International Convention Centre in Cape Town), has once again excluded the true owners of the land from their conference, and warn that severe hardship, social conflicts and unsustainability will result when our land and heritage is sold at the altar of foreign governments and transnational corporations. We stand in solidarity with workers, women and men, young and old, who have lost their lives and livelihoods as a result of unscrupulous mining companies, and demand the protection of the rights of communities and particularly the defenders of rights, who continuously suffer under oppressive regimes . . ." [<http://www.news24.com/Archives/City-Press/Alternative-Mining-Indaba-calls-for-inclusion-of-communities-20150429>] (accessed on 11 March 2016). The African Mining Indaba is an annual professional conference dedicated to the capitalization and development of mining interests in Africa.

Beierle (1999) [80], and Beierle and Konisky (2001) [81] examine the need to increase public participation in environmental decision-making processes, and propose the use of a framework that evaluates the outcomes of participatory processes using a set of six "social" goals which they match to the participatory mechanisms by which these goals might be achieved. These authors conclude by outlining areas for further research that are suggested by the framework.

Fostering public participation would enable the affected communities recognize the vital importance of the mining industry to modern society and to the local economy, and continue to expect responsible stewardship of the environment by this essential industry. Goodland (2012) [82] and CER (2013) [83] take the need for inclusivity a step further by advocating that communities be afforded a chance to actually participate in the data collection and their interpretation as well, and not merely make an appearance in public meetings.

5.2. The Place of Women on the Table

Women, in particular, must be encouraged to participate in decision making processes as well as on all negotiations concerning the development of tailings facilities and other mining related activities. This should be as a natural consequence of their traditional role in acquiring most of the elements needed for ensuring family sustenance. They constitute the higher proportion of primary care givers for those affected by improper tailings handling and other mining impacts (See Section 2.3, this article). McGuire (2003) [27] corroborates these assertions and emphasizes that women need to be better informed about these impacts, and their interests and welfare made part of the agenda in mining indabas.

6. Addressing the Issues

It is clear from a retrospective look at the state of tailings dams around the country, and the evolution of practices and expectations, that improvements have been made in some areas of concern. Reporting on environmental and social issues has improved. However, there remains much room for improvement in crafting and revising legal codes, and for seeking better ways of articulating existing regulatory instruments for tailings management for the protection of the environmental health of exposed populations. Current project management models for the development and management of these facilities such as those proposed by Robins (2004) [84] and Fourie and Brent (2008) [85] do not as yet provide a holistic approach to integrate the requirements of the various existing regulatory statutes during the various project life cycle phases (from EIA process and pre-mining, right up to mine post-closure). Such failings have a dreadful effect on sustainable development of mining communities.

We submit in summary form, five imperatives on responsible tailings management that hopefully would contribute in future review and articulation of modes of tailings disposal statutes in South Africa.

6.1. Imperative 1: Giving the Devil His Due, but Coming Out Strongly on Defaulters

There exist a number of mining industry operators that deserve praise for their efforts towards the proper management of tailings. Cite, and acknowledge them. Concentrate on factual accounts of incidents to develop and maintain credibility. There are some non-government organizations that endorse actions against corporations committed to a high degree of environmental stewardship, and who operate their mines and tailings facilities accordingly. These organizations should never be supported.

However, it is important to distinguish between the improvements in standards and norms, and real improvements in performance (e.g., [86]). The same can be said for improvements in reporting and transparency versus improvements in minimizing negative impacts from improper tailings disposal and other mine waste removal practices.

In this connection, we have to stress the emergence of disturbing trends in the legal framework, with insufficient government involvement in environmental assessment. Although these trends are hard to quantify, we do not see any real indication that the number of on-the-ground social conflicts are decreasing, suggesting that the performance of the sector still has a long-way to go. Legal compliance to ensure protection of human health and environment and prevention of pollution is essential. Many environmental activists would like to see application of the “polluter pays principle” whereby industries and polluters are forced to take full responsibility for the pollution they cause. It is possible for civil society and the relevant organs of state to co-operate in holding mining companies responsible and liable for alleged environmental contraventions and failure in their duty of care.

6.2. Imperative 2: Create a Strong Stakeholder Management Base

The success of responsible tailings management depends on the collective actions by all key stakeholders (Section 2.1, this article). The mining corporate has however, additional responsibilities,

in ensuring that it conducts its business in a way that ensures the promotion of high moral and environmental etiquette among workers.

In the South African context, responsible mining would promote relationships between various stakeholders involved or affected by tailings management as well as other mining operations.

To avoid the manifestation of undue risks and ensure the optimization of resource exploitation, owners of mines and practitioners of tailings disposal must conduct disposal practices in accordance with fundamental safety and environmental objectives and principles as laid out in a set of performance criteria. Mine owners should move from an end-of-pipe approach to tailings management to a more integrative approach, recognizing that effective tailings management must begin in the extraction process, not at the end of the pipe. It is important to recognize the critical importance of making the right decisions at the outset of a project, and accounting for long-term closure costs and liabilities in financial evaluations of existing and potential projects.

Prior to business operations beginning, a local barometer should be used, drawing expertise from civil society to ascertain potential human rights impacts as they pertain to the social, economic, environmental and health consequences of operations. Government and the community should work together to the extent that a project that fails to garner consensus from all stakeholders should not be allowed to proceed.

6.3. Imperative 3: Strengthen Regulatory Measures

The South African regulatory framework (Figure 5) provides for the operation and monitoring of the activities pertaining to environment and human health. These are source documents that need to be understood and consulted to address activities that have a potential to harm human health and degrade the environment.

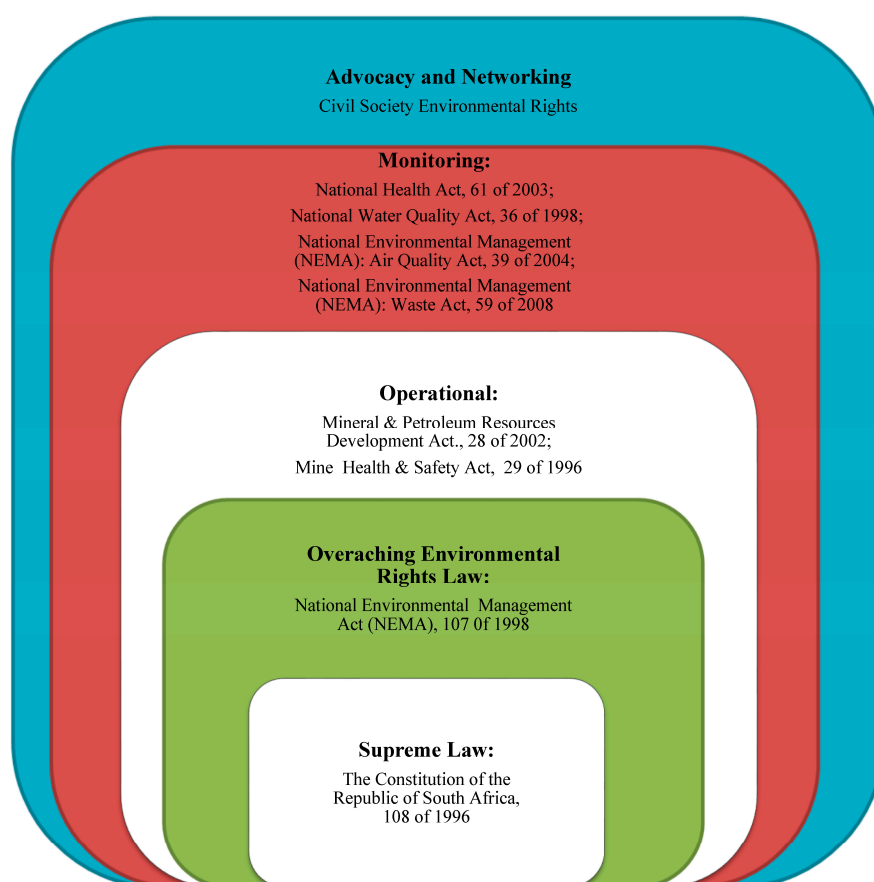


Figure 5. A proposed South African regulatory framework relevant to responsible tailings management.

It is recommended that regulators establish and maintain a database on all tailings dams, operating and otherwise, within their jurisdiction. Honest assessments of the performance records of owners and designers should be made, and the details shared with other regulators as appropriate. They should facilitate development where the owner presents an independently reviewed design that is consistent with standard design criteria.

Having different state agents in charge of different legislative controls often creates problems, such as causing delays in the handling of complaints, with the attendant inconvenience to the public who are unable to identify the appropriate authority to approach for redress. Monitoring could be strengthened by having a mechanism in place that would ensure that different government departments collaborate in dealing with mine tailings management complaints.

6.4. Imperative 4: Promote an Ethical Mining Culture

The creation of an ethical culture within the mining companies demands the companies' commitment to understand and uphold the current applicable statutory requirements. Ethical culture in the mining companies guarantees that justice is done for all affected parties and in all circumstances. Figure 6 provides a summary of key ethical elements essential for creating an ethical mining culture.



Figure 6. Suggested key elements for an ethical tailings disposal practice in South Africa.

An ethical mining culture would promote the development of strategies that deal with unintended consequences. The ethical principles of beneficence and non-maleficence, and indeed, their application, would restore the dignity of the people.

The benefits of responsible tailings disposal can only be derived when mine operators faithfully apply principles designed to avoid hazards and the creation of a conflict-free relationship between the local communities, the mining industry and the government.

6.5. Imperative 5: Tailings Should be Usefully Applied

Although the operation of South Africa's tailings dams goes as far back as the early 1960's, there is still uncertainty with regard to the sustainability of the vegetation cover established using different rehabilitation methods; and there remains a general dearth of research and knowledge on the different rehabilitation technologies. In the field of "phytoremediation", however, South African researchers are among the leaders. This green technology is being developed by a number of mining

companies in the country, such as AngloGold Ashanti and Rustenberg Base Metals Refiners. The technology involves growing “tolerant plants” in a contaminated matrix to remove environmental toxicants by immobilization (phytostabilization) or extraction (phytoextraction) [87,88]. One of the main advantages of phytoremediation is that of its relatively low cost compared to other remedial methods such as excavation.

Berkheya coddii Roessler (*Asteraceae*), an endemic herbaceous and perennial nickel-accumulating plant grows on Ni enriched ultramafic soils in South Africa. This plant is perceived as a promising species for phytoremediation and phytomining due to its large biomass production and high nickel content. *B. coddii*, is presently cultivated commercially by Rustenberg Base Metals Refiners, and has been tested for phytoremediation of cadmium, nickel, zinc and lead from industrial tailings and wastewater effluents at disposal sites [89]. AngloGold Ashanti is also looking at the use of indigenous vegetation to prevent pollution in the form of dust and AMD from tailings dams.

Mineral tailings produced by a number of South Africa’s mines are composed of silicates, oxides and sulphides. A number of researchers have applied engineering techniques to study the potential of these materials to be recycled into innovative schemes designed to reduce their footprint and to evaluate their suitability for mineral carbonation, e.g., [90], and for brick-making, e.g., [91].

Mentjes (2014) [92] has reviewed the benefits of dry tailings disposal as one of the most water-efficient waste management systems, and has advocated the consideration of their use for both existing and new mining projects. To achieve real cost benefits, it is necessary to integrate the design of process plant with that of tailings disposal while giving consideration to all design aspects, from site selection to closure of tailings impoundments. Meintjes (2014) [92] also discusses the geotechnical properties of tailings and shows how water savings can be made and groundwater pollution reduced by changing the tailings from wet slurry into a dry product.

Some mining companies are now exploring the advantages of re-processing of legacy tailings resources to extract minerals such as uranium and gold. The technique is becoming attractive, because of the potential to maintain margins and unlock profit. Tailings reprocessing is also viewed favorably from an environmental standpoint, in that it allows for additional production without increasing a mine’s footprint. It provides a platform for advancing research in re-processing technology and phytoremediation, and does not require additional land permits.

The problems associated with mine tailings disposal, both operational and legal, are not just specific to South Africa. Novel techniques are currently under development elsewhere on the use of such materials on an industrial and global scale to sequester ambient CO₂, while research on the topic is constantly expanding. Ultramafic mining residues produced during mining operations around the world, such as in stockpiles, may offer a long-term solid storage buffer of atmospheric CO₂ [93].

Assima et al. (2013) [94] have made a comparative study of five Québec (Canada) ultramafic mining residues for use in direct ambient carbon dioxide mineral sequestration. A number of studies outside South Africa have also estimated other ultramafic mining residues that contain high enough amounts of magnesium (12–19 wt. %) able to chemically bind to ambient CO₂ *via* above-ground natural weathering mechanisms (e.g., [95]).

Experiences and lessons learned from applications in other top mining countries (e.g., Australia, Canada) can be applied to South Africa today.

7. Conclusions

Safe and environmentally responsible disposal of mine tailings is a major concern in South Africa’s mining industry. The extent of the legacy of negative environmental and human health impacts is hard to quantify precisely. But we know that the amount of tailings produced by low grade, high tonnage operations is huge; and it is progressively increasing its environmental footprint.

This study has shown that South Africa has made significant progress in directing legal and policy frameworks to address the ethics of tailings disposal. However, there still exist areas of vulnerabilities in the current system, as well as areas where there is non-alignment of the ethics of

tailings management by mining companies with the government's current legislations (on tailings handling). There are instances where existing legislations have not provided full justice to communities suffering from socio-economic and health problems due to their exposure to tailings. Articulation of regulations on tailings management has not protected the rights of women in mining as communities or as workers.

A review of the evolution of South Africa's regulatory codes and the ethical position, as well as the behavior of major mining companies in the area of tailings management, shows that, despite the new constitutional reforms, environmental management of tailings is still not strictly regulated, lax, nor enforced, or is overruled for several reasons. An overview of their contents and soundness, as well as their impact, is given in this study—the many loop-holes, the vestiges of exploitative colonial mining laws that remain entrenched in the older legislations (before mid-1990s); and areas where the newer legislations (after the mid-1990s) fall short of adequately addressing constitutional and environmental requirements. Other aspects of the minerals legislation are shown to be in need of clarification or further development.

The nature of the ethical concerns and the magnitude of the environmental and health hazards posed to South Africans by improper tailings management points to the conclusion that mining companies should uphold their own responsibility for the protection of the environment and our planet for the sake of present and future generations. Mining corporations are seldom held accountable for many of the social, environmental and health burdens that improper tailings handling impose on society. The line between what is their responsibility and what is not, is still very blurred. There are still low levels of accountability, transparency and commitment in all aspects related to CSR and sustainable development in tailings handling.

A number of large mining institutions including foreign consortiums, have drafted their own corporate codes of conduct, but the status of these codes is unclear, and their operationalization not efficient enough to address the regulatory challenges taking place globally. It is clear from this study that many large mining companies use CSR politically to prevent the introduction of legally enforceable tailings disposal control measures which have a proven record of effectiveness in other top mining countries such as Australia and Canada.

There is thus a clear need for a systematic approach to address these mammoth challenges. The core ethical principles of tailings management apply across the world, and deep knowledge and experience of the potential impacts are essential to readily transfer and monitor these principles adroitly, so that applications ensure ethical sanctity. In addition to these guidelines and regulations, procedures for safety management and documentation successfully applied in other high-risk industries should be adopted for operation of tailings impoundments. It is possible to design, operate, and close these facilities safely, and in ways that protect the environment.

Finally, the useful applications of tailings, such as in mineral recovery from historic dams, and the rock cladding of tailings dams for controlling wind and water (rainfall), as well as for stabilizing the slope of a mine dump, should be given more research attention. The use of re-vegetation in conjunction with rock cladding on mine dumps should be further explored.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Case Study 1: Causes and Consequences of the Merriespruit Tailings Dam Failure

Excerpted from: Van Niekerk and Viljoen, 2005 [96] (Direct quotation).

“On the night of 22 February 1994, the 31 m high northern wall of the number four tailings dam of the Harmony Gold mine collapsed. The tailings dam is situated 320 m up-slope of Merriespruit, a suburb of Virginia in the Free State Goldfields of South Africa. More than 2.5 million tonnes of liquefied tailings ripped through the sleeping mining village. Eighty houses were largely swept away and 200 others were severely damaged. Seventeen people were killed. The failure of this tailings dam shocked everybody who followed the unfolding drama of loss of life and destruction of property in the press. At the inquest following the disaster, the judge called this tailings dam a time bomb that was waiting to explode. For the first time in South African history, processed satellite images were allowed as scientific evidence in court. Together with eyewitness reports, all the evidence pointed overwhelmingly to the cause of the failure as being overtopping. The owner, the operator and six of their employees were subsequently found guilty of negligence (contravening Section 37 of the Minerals Act), and heavy fines were imposed. The Merriespruit disaster provided the State and the mining industry with the impetus to ensure the safe disposal of tailings. It also made the mining industry and all those involved with the design and operation of tailings dams take stock of their management and tailing disposal methods”.



Figure A1. Aerial view of the Merriespruit tailings dam disaster. Approximate volume of the dam = 2.5 million cubic meters. Source: Tailings.info. Available online: <http://www.tailings.info/casestudies/merriespruit.htm> (accessed on 26 March 2016).

Appendix B. Case Study 2: Interviews with Tudor Shaft Community Members—17 January 2013

Excerpted from: Caincross et al., 2013 [97] (Direct quotation).

“About 2000 residents continue to live in shacks on a gold mine tailings dump. A recent soil sample analysis requested by the Federation for a Sustainable Environment showed elevated levels of aluminium, arsenic, cadmium, cobalt, copper, mercury, manganese, nickel, zinc and uranium. An independent international expert in 2011 found radiation levels 15 times higher than the regulated level. He advised on the immediate relocation of the community. The National Nuclear Regulator of South Africa confirmed the grounds were indeed radioactive and Parliament recommended relocation of the community in

2011. The majority of them are still living here. No health outcome studies related to the exposure of the community to high levels of radiation is as yet available. Here is what community members had to say: We have been living here for up to 10 years. Our children are sick from birth with flu and chest problems. I have to take my 9 month old son to the clinic almost every week with a runny nose and cough. The water is not good and there is only 4 taps for all of us. Children commonly have vomiting and diarrhoea. Toilets are broken and never clean and too few for all of us living here. Itching of the skin is common and worse for children. TB is getting worse. The dust from the new mining on the dumps makes coughing worse. We attend the clinic but the treatment for TB is not helping anymore. We have no electricity for cooking. Cooking with paraffin and coal is bad for the flu and dangerous for fires. In winter it is worse when it is very cold. We have toyi-toyi'd and have attended many meetings. We get promises for new stands but we are still here. Our story have been in the newspapers. A few families have been given houses near Kagiso. This is the start of a new year and we are hopeful for new homes. An elderly woman next to the Tudor dam explained that mining now started right next to her home. She worked for about 45 years as a domestic worker and now lives next to the mine dumps. She is suffering from high blood pressure and has very poor eyesight. She has no running water in her home and no electricity. The future is uncertain. No-one has come to talk to her about the new mining or the relocation. During the interview we heard the deafening sounds of nearby mine blasts".

Appendix C. Case Study 3. "The Legacy of Gold Mining Activities around Johannesburg"

Excerpted from: Tutu et al., 2003 [98] (Direct quotation).

"The legacy of gold mining activities around Johannesburg consists of enormous heaps of tailings dumps extending over many square kilometres. These sites must be considered as potential sources of mobile uranium to the biosphere. Gamma spectrometric analysis points to significant leaching of U from tailings dumps. This has caused some radioactive disequilibrium as U has been decoupled from the decay series. Very high concentrations were obtained in water bodies in the proximity of tailings dumps whereas significant attenuation was realized in areas far from the sources. The processing of mine dumps has also contributed to enhancing acid drainage and probably oxidation of dump material, thus enhancing U mobility. Wetland sediments showed that they act as traps or sinks for U and other heavy metals, this being strongly demonstrated by BCR (the Community Bureau of Reference) sequential extraction. The oxide-bound fractions from this protocol point to co-precipitation as the main U removal process from the water column. It should be noted that the toxicity of U is not as a result of its radioactive nature, but rather its chemical nature. The kidney is considered the target organ for uranium's chemical toxicity".

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